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Patterns of Distribution and Seed Predation in a Population of *Pritchardia hillebrandii*

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A fruit consists of an endosperm and embryo surrounded by a hard endocarp which is surrounded by a fleshy mesocarp and/or exocarp. In mainland, tropical forests, fruit is both temporally and spatially abundant. Numerous vertebrates ingest fruits without reducing seed viability and may benefit the plant by dispersing those seeds. However, seed predators often destroy the majority of seeds of large-seeded plants (Janzen 1971, Smythe 1989).

Both vertebrates and invertebrates attack and destroy seeds. Vertebrate seed predators include: pigs (Lott et al. 1995), rats (Janzen 1971) and caviomorph rodents (Smythe 1989). Mammals can substantially reduce recruitment of all plants with edible seeds. The invertebrate seed predators tend to be specific to single plant species, or a set of closely related species. Depending on seed size, one or many invertebrate larva may colonize and destroy a seed. Invertebrate seed predators are most often beetle species (Janzen 1977), but lepidopteran and dipteran species also attack seeds (Szentesi and Jermy 1995).

These seed predators often are density- or distance-responsive, destroying a larger proportion of seeds near the seed source than away from it (Lott et al. 1995). Seed density is usually greatest under the canopy of the source tree and a higher proportion of these

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seeds are destroyed than of the seeds that are distributed away from this canopy. Seed dispersers can provide an escape from predation by increasing both the distance and number of dispersed seeds.

The flora of remote islands is determined through chance colonization by wind blown, water-borne or biotically dispersed seeds that, once established, may radiate extensively. The assemblage of species that results from this can be rather random. While most large seeded plants do not reach remote islands, some do. It is unlikely that these species bring their invertebrate seed predators with them, and they may experience much greater reproductive success on islands. However, other seed predators may take the place of the predators left behind. There is very little published information on whether island plants do have depauperate invertebrate seed predator faunas.

The genus *Pritchardia* (family Arecaceae) is the only palm native to the Hawaiian archipelago. The genus contains about 25 species located on the tropical Pacific islands of Fiji, Samoa, Tonga, Tuamotus and Hawai'i. Nineteen of the 25 species are endemic to Hawai'i and one or more species can be found on all the main islands (Wagner et al. 1990). In this study we chose to examine the seeds of *Pritchardia* palms, to investigate levels of seed predation, and the distribution of one species, *P. beccariana,* to quantify patterns of seed predation and adult distribution in the field. We were interested in the following questions: 1) What are the seed predators of Hawaiian *Pritchardia* species? 2) What is the impact of these seed predators on the survival of *Pritchardia* seeds? 3) Is the distribution of seedling and adult trees reflective of seed predation patterns?

METHODS

Invertebrate Seed Predation. *Pritchardia* fruit were collected from a number of sites on the Big Island and O'ahu (Table 1). Fruit were usually collected from the ground whenever entire, fairly fresh fruit were present there, but in some instances fruit were picked from the trees. The fruits of *Pritchardia martii* were collected from two fruiting trees on Aiea Ridge Trail, O'ahu. *P. beccariana* fruits were collected on three dates from a wild population along the Stainback Highway on the Big Island. On August 31, 1996 five fruits were collected from two trees at approximately 2800 feet; on October 31, seven mature fruits were collected from two trees at 2400 feet. In addition, ten partly rotting fruits were collected from the ground under these two trees. On November 23, 21 fruit were collected from seven trees at 1900-2700 feet elevation along the highway. Mature fruits from two trees at Lyon Arboretum, O'ahu were collected on September 24, 1996. These two trees were not species native to O'ahu. They were: *P. hillebrandii* which is found on Moloka'i and *P. beccariana* which is found on the island of Hawai'i. Some of these fruits may have been hybrids between these two individuals. Fruits were collected from an individual of the Nihoan, *P. remota*, at St. John Hall on the University of Hawai'i campus. On December 2, 1996 six fruit were collected from an individual of *P. affinis* at Pu'u Honua O Honaunau National Historic Park, Hawai'i.

Collected fruits were kept in sealed ziplock bags or plastic containers. Fruits collected from different dates were kept separately. The fruits remained moist in the sealed bags, but two set of fruits were allowed to dry out. The fruits were checked daily to determine whether any invertebrates had emerged. Pupa were collected and placed in separate vials until adults emerged. Some fruit were dissected before invertebrates had emerged from them. Invertebrates were identified as specifically as possible and we attempted to ascertain whether the species were native or not.

Pritchardia beccariana *Distribution.* Distributional data was collected from a population of *P. beccariana* located along the Stainback Highway on the island of Hawai'i. We surveyed a transect 25 meters wide, on each side of the road, from the intersection of North Kulani Road with the Stainback Highway proceding in a southwest direction for 6.7 km. Adult trees were mapped by recording 1) the distance (m) from the road to the nearest tree (n=15) and 2) distance (m) and compass angle from that tree to each neighboring adult tree (n=24). Data were collected for all trees on the number and developmental state of all visible fruits and flowers. Fallen fruits located within an approximate 1 m radius of the fruiting body of each palm were temporarily collected and

Table 1. *Pritchardia* fruit collections.

Species	Collection Location	Date Collected	No. of Fruits	No. of Invertebrates*
P. affinis	Pu'u Honua, Hawai'i	6 Dec 96	6	60 (sealed)
P. beccariana	Lyon Arboretum, O'ahu	17 Sep 96	10	0 (air dried)
	Stainback Hwy, Hawai'i	31 Aug 96	5	2 (sealed)
	Stainback Hwy, Hawai'i	31 Oct 96	7 (10 rotten)	52 (sealed)
	Stainback Hwy, Hawai'i	23 Nov 96	21	35 (sealed)
P. hillebrandii	Lyon Arboretum, O'ahu	17 Sep 96	26	29 (sealed)
P. martii	Aiea Hts. Trail, O'ahu	5 Oct 96	50 (green)	0 (sealed)
P. remota	St. John Hall, O'ahu	17 Sep 96	6	0 (air dried)

* Fruits were sealed in ziplock bags or air dried in ventilated containers and observed for invertebrates.

scored according to presence or absence of the following traits/damage: 1) germination, 2) vertebrate damage, 3) invertebrate damage, and 4) unknown cause of damage/decomposition. The presence or absence of seedlings was also noted within a 3 m radius of each adult tree.

RESULTS

Seed Predation. No invertebrates emerged from the fruit which were allowed to dry out (Table 1). In addition, *Pritchardia martii* fruits were collected when immature and green and no invertebrates have emerged from these fruits.

A variety of invertebrates emerged from the remaining *Pritchardia* fruit collections (Table 1 and Appendix 1). The first collection of five *P. beccariana* fruits from the Stainback Highway yielded two lepidoptera pupae, one of which died before emerging, and one of which hatched out a hymenopteran parasitoid. The first lepidopteran larvae remained visible on the *Pritchardia* fruit for over 2 weeks, and consumed much of the outer pulp of three fruits. On December 6, the second collection of fruits from the Stainback Highway had visible punctures on the surface of the skin of two fruits that suggest the presence of mining invertebrates. One larvae did emerge, but died. Two of these fruit were dissected revealing 2 Scolytid beetles (family Scolytidae, genus *Coccotrypes persicae* (Hopkins)) boring into the endosperm. A number of invertebrates have also emerged from the third Stainback collection. Between 5 January and 20 February 1997, 15 adult Micropezid diptera (family Micropezidae, *Taeniaptera angulata*) emerged. Also, 13 adult Coccotrypes persicae, three Drosophila melanogaster, one Nitidulid beetle, two unidentified earwigs (family Dermaptera), and two undetermined invertebrates have also emerged. There have also been two undetermined Coleopteran larvae which emerged from the fruit and died. The rotten fruits had visible, fresh frass on December 6, and seven of the Scolytidae *C. persicae* beetles were found, consuming the endosperm of two of the partially intact seeds. There was also one fly which emerged and an unidentified lepidopteran pupa which died.

We examined the ten fallen, partially rotten *P. beccariana* fruit for presence of invertebrate consumers. Nine of the seeds were already completely consumed with large masses of frass inside the endocarp, or were entirely rotten inside. Eight of the Scolytidae were present between the endocarp and mesocarp of two fruit. The final fruit had a partially intact endosperm within the endocarp. We extracted 35 Scolytids from this single endosperm. Their feeding tracks were clearly visible and it was obvious that they were destroying the seed, and not the fruit. To assess whether they were secondary colonizers of an already damaged fruit, or the primary predators, on December 6, we dissected two of the fresh fruit collected on October 31. Both of these fruit had single Scolytids (*C. persicae*) which had begun to tunnel into the endosperm. Except for these beetles, the fruits were undamaged and no other invertebrates were found.

The *P. hillebrandii* fruits collected at Lyon Arboretum have yielded the most interesting results on the invertebrate fauna of *Pritchardia* fruit. 2 individuals of an introduced Nitiidulidae species and 8 Antribids (family Anthribidae,

species *Araecerus fasculatus* (DeGeer), one native Gelechiidae lepidoptera (family Gelechiidae, genus *Thyrocopa*), and 18 individuals of one introduced Otitiidae diptera species [family Otitiidae, species *Acrosticta apicalis* (Wiliiston)] have all emerged from the 23 fruits collected.

The *P. remota* fruit collected on the first date were kept in a ventilated container and, again, no invertebrates emerged. The second collection, kept in a sealed plastic bag, has yielded a single Diptera (species *Drosophila melanogaster)* adult.

All seeds from the *P. affinis* collection were dissected on February 10, 1997 and 19 Scolytidae (genus *Hypothenemus*) and 2 Anthribid beetles (*Araecerus fasciculatus* (DeGeer)) were removed from the fruit. These individuals were feeding on the dried, woody, fruit pulp and had not penetrated the extremely hard endocarp of these seeds. The Anthribid beetle was the same species that was recovered from the *P. hillebrandii* on OÔahu, but the Scolytid was distinctly different from the *P. beccariana* Scolytid and is probably a native species (A. Samuelson, pers. comm.).

All of these invertebrates emerged from fruit which contain both the seed and varying amounts of fruit pulp. Invertebrates which feed solely on pulp are unlikely to affect subsequent germination of seeds. It is impossible to be certain which species in this study were fruit feeders or seed predators, but there was some evidence that allowed tentative placement of some of the species. Probable fruit feeders (which do not damage the seed) were the Drosophilid and Otitid flies, the Nitidulid beetle, and the Gelechiid moth. Seed feeders included the Anthribid beetles, the Scolytid beetles, and the unidentified, dead Coleopteran larvae all of which emerged from exit holes which originated within the endocarp. Additionally, the native *Hypothenemus* sp. of Scolytid did not appear to be damaging the seed, whereas the introduced *Coccotrypes persicae* Scolytid was usually found inside the endocarp.

There is a large enough sample of the Otitid diptera to make some preliminary descriptions of their life history. The *Pritchardia* fruit were collected on September 17 from Lyon Arboretum, OÔahu. Fly larvae were not observed during the first three weeks, but were visible, moving on the outside of the fruit, by October 15. The first larvae pupated on October 23 and as of December 6, there were no unpupated larvae. We used September 17 as the last possible date that eggs were laid by an adult. The average time to pupation was 51.18 days (n=14). Since the eggs were most likely laid before this date, the larval period was probably longer. A total of 14 pupae were found of which 12 hatched. Emergence from the pupa occurred between 8-13 days with a mean time of 10.4 days (n=12). At least four pupa went undetected as four adult flies were found in late November in with the fruit. All adult flies died within 3 days of emergence.

State of Fallen Fruit. Twenty of the 36 live *P. beccariana* trees surveyed had fallen fruit underneath their canopies (Fig. 1) and 19 trees had green fruit on their inflorescences (Fig. 2). The mean fruit crop size for all trees was 20.0 fruit. The mean fruit crop size for those trees with fruit was 36.0. The average number of fallen fruit under all trees was 5.25 fruit. There were an average of 9.45 fallen fruit under those trees with any fallen fruit. Most trees bearing fruit also had fruit on the ground. The correlation between standing fruit crop and

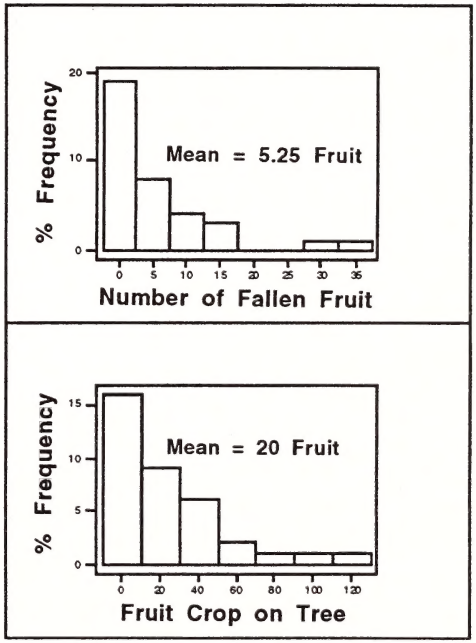

Fig. 1 and 2. Histograms of fallen and standing fruitcrops for *P. beccariana.*

number of fallen fruit was .749, which suggests that the fallen fruit are all from the most recent fruiting event. In a subsequent analysis, the number of fallen fruit and standing fruit was summed for each tree to give a "total" fruitcrop. Total fruitcrops were not significantly different between the low and high elevation trees (2-sample T-test: T=1.65, P=0.11, df= 26) nor were they significantly different between *Pritchardia* in clusters of different sizes. Overall, trees at different elevations and in different cluster sizes did not show any difference from one another in phenology.

Out of 189 fallen fruit examined, only three were potentially viable and all of these were green fruit (Fig. 3). Seeds which fall when green turn brown within 4 days so these fruit had probably not been on the ground for long. One of the green fruit had approximately half of its fruit pulp removed by an unidentified rodent, most probably a rat. A tentative cause of mortality was determined for the remaining 185 fruit. 62.8% of all fallen fruit had been attacked by invertebrates with numerous exit/entrance holes per fruit. The number of holes on 10 fruit ranged from 3 to 17 with a mean of 8.5 holes. These holes were generally of two sizes: less than 1 mm, and between 1.5-3 mm in diameter. At least some of the small holes were from the Scolytid beetles. In many cases a small proportion of the hard endosperm remained inside the partially entire mesocarp.

Rodents had damaged the fruit or seeds of 26.7% of fruit (Fig. 3). Many of the rodent damaged fruit had also been damaged by invertebrates. It was not possible to assign a cause of mortality for 23.6% of the fruit/seeds.

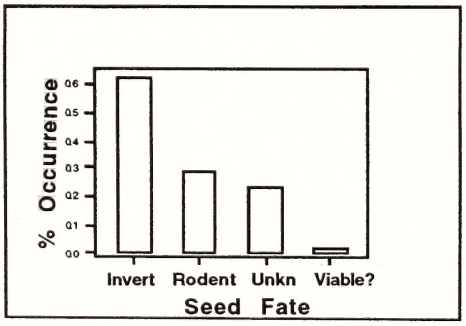

Fig. 3. Status of fallen fruit (predation and viability).

In sum, the seeds of 186 of 189 of fallen fruit were destroyed with no chance of germination.

There are two components to seed density which seed predators may or may not respond to. They are: the number of seeds per tree and the number of trees in a given area. Since almost all seeds were predated it was impossible to assess whether all seed predators together were responding in a density dependent fashion. However, it was possible to assess whether separate seed predators respond to seed density under a tree or in a tree cluster. These data show that the levels of vertebrate predation increased with increasing number of fallen fruit beneath a single tree (Fig. 4). Levels of invertebrate predation did not show the same pattern (Fig. 5).

To assess whether predators were responding to seed density within an area we examined the relationship between seed predation levels and number of trees in a cluster. There was no clear pattern between vertebrate predation levels and cluster size (Fig. 6), but there was a correlation (0.317) between invertebrate predation and number of *Pritchardia* in a cluster (Fig. 7).

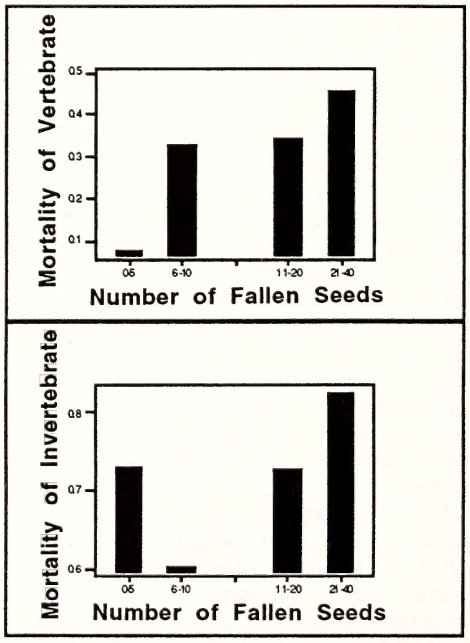

Fig. 4 and 5. Vertebrate and invertebrate predation levels by number of fallen fruit.

The elevational gradient present across these transects could confound the density dependent responses described above. There were apparent trends between the percent of fallen fruit attacked by invertebrates and by vertebrates with elevation (Fig. 8). The percent of fruit that were invertebrate attacked was higher for the upper 19 trees on the transects. Conversely, the percent of fruit attacked by vertebrates decreased for the upper 19 trees. Neither of these patterns were significant (2-sample T for percent invertebrate predation: T= -1.36 p=0.19 df= 13; % Vertebrate Predation: T= 1.43 p=0.18 df= 13).

We used regression analysis to assess whether number of fruit, number of trees in a cluster, and elevation, when considered together, are good predictors of invertebrate or vertebrate seed predation levels. Number of fallen seeds, number of trees in the cluster, and elevation were all significant predictors of invertebrate seed predation levels (Table 2).

None of these factors were significant predictors of vertebrate seed predation levels (Table 2). However, in a second regression, with only number of fallen seeds as an explanatory variable, the regression was highly significant (p=0.029). Invertebrate and vertebrate predation increased, as expected, with increasing seed number (and for invertebrates, with increasing group size). However, the coefficient for the elevation term was positive indicating that invertebrate predation increased with elevation. This result was not expected.

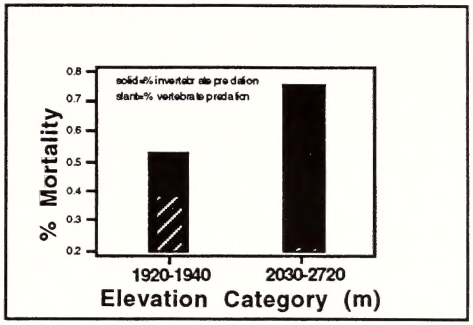

Fig. 8. Percent Fallen Fruit Predated by Elevation Category.

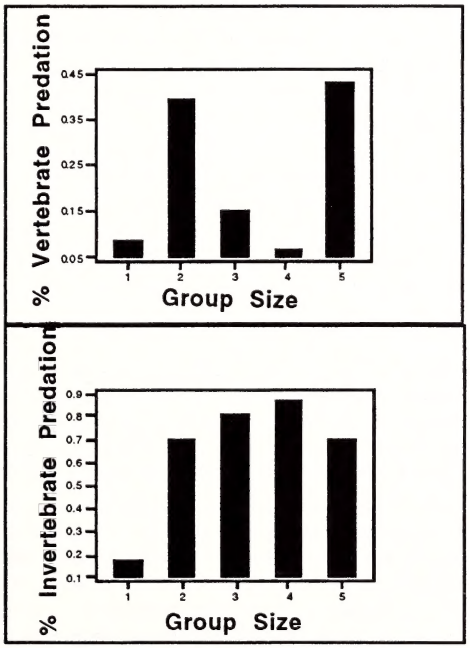

Fig. 6 and 7. Vertebrate and invertebrate predation levels by number of *Pritchardia* in a cluster.

Adult and Seedling Distribution. All adult trees were mapped in relation to their kilometer position along Stainback Highway and their distance in meters from the road [for the first tree in each clump (n=15)] or by their position (distance in meters and compass angle) relative to the first tree in each clump (n=24) (Fig. 9). The results show a two-scale pattern of clumping. Along the elevational gradient corresponding with the southwesterly direction of the Stainback Highway, trees formed five clusters (labeled cluster A-E) with several clumps within each cluster. On the smaller scale trees, trees within clusters A-E, were also located in clumps (labeled 1-15).

Distances between clumps were compared to distances between neighboring trees within a clump (Table 3). The mean distance between clumps (μbetween) was 277.4 meters while the mean distance between trees within the same clump (μwithin) was 8.24 m. The hypothesis that distances between clumps are greater on average than distances between trees within the same clump was tested via a two-sample t-test, with a 95% CI for μwithin-μbetween =(-473.5, -65), P=0.0069 and df=13.

Only three seedlings were documented from all 39 trees surveyed. Two of the three

Table 2. *p*-values and regression statistics determined for invertebrate and vertebrate predations.

Predictor	Invert. Pred.	Vert. Pred.	Vert. Pred.
Constant (*p*-value)	0.055	0.356	0.072
No. of Seeds	0.006	0.129	0.029
Group Size	0.027	0.431	---
Elevation	0.003	0.354	---
Adj. R^2 (%)	46.0	19.4	20.7
Regression df	3	3	1
Total df	18	18	18
Total P	0.006	0.104	0.029

Table 3. Mean, median and standard deviation of distances (m) between the first trees in each of the clumps (n=15), distances (m) between first tree in each clump and its neighbor (n=24), and distances (m) of seedlings from parent trees.

	Mean	Median	St. Dev.
Between	277.4	156.7	353.9
Within	8.2	6.6	5.6
Seedling Distance	1.17	1.00	0.29

seedlings were found on a nurse log located under one tree and all three seedlings were from trees at the maximum elevation surveyed (2720 ft).

DISCUSSION

There is a diverse and abundant invertebrate seed predator fauna of Hawaiian *Pritchardia* species. Some native species were found attacking seeds, but the majority of the species were introduced. Introduced rodents are also important seed predators of wild *Pritchardia*. In the wild, levels of predation appear to be high enough to preclude any seed survival for many reproductive adults and recruitment may be almost completely disrupted by a bottleneck at the seed and germination stage. Similar drastic reductions in recruitment have been found for other tropical species in human-altered habitats (DeSteven and Putz 1984, Smythe 1989).

Invertebrates living on *Pritchardia* fruits were from the orders: Diptera, Coleoptera, Dermaptera, Hymenoptera, and Lepidoptera. Beetles are the most likely seed destroyers with the other species feeding on parts of the fruit. Beetles are important seed predators in many tropical and temperate areas (Szentesi and Jermy 1995, Siemens and Johnson 1996, Janzen 1980).

The impact of both vertebrate and invertebrate seed predators increased with seed density. Vertebrate predation increased with the number of seeds under a tree, while invertebrate predation increased with both number of seeds under a tree and number of trees in a patch. Vertebrates, in this case rats, are probably not dependent on *Pritchardia* seeds. Invertebrate species may only feed on *Pritchardia* fruit and seed. If there are more trees in an area, it is more likely that there will be a fruit supply throughout the year. Tree species in many tropical areas display a high degree of intra-specific fruiting synchrony and it has been suggested that this is a strategy to satiate seed predators and to prevent substantial seed predator populations from building up (DeSteven 1983, Gorchov 1988). *Pritchardia* species appear to be highly asynchronous with individuals fruiting almost continuously throughout the year (Wagner 1990). This may make them particularly susceptible to invertebrate seed predation. It is impossible to test this prediction of asynchronous fruiting without controlled experiments, but it does appear that invertebrates have a drastic effect on *Pritchardia* seed survival.

The data provided by this study implicate a current mechanism of gravity dependent seed dispersal. This conclusion is supported by the distributional results showing a two-scale pattern of clumping, along both an elevational and localized gradient. The phenomenon of localized clumping is illustrated by the two sample t-test (P=0.0069) showing a greater mean distance between clumps (μ between) than between trees within the same clump (μ within).

The only potential, extant biotic dispersal vector of *Pritchardia* is the Hawai'ian Crow (*Corvus hawaiiensis*) Potential extinct dispersers include the: large species of flightless geese (Family Anatidae), two *Corvus* species (Family Corvidae), and a few of the Drepanids (Family Fringillidae). The diet of these species is completely unknown but their gape sizes were large enough to swallow or carry *Pritchardia* fruit (Olson and James 1991). It is also possible that hurricanes disperse *Pritchardia* seeds from plants in exposed or high elevation areas. Current, gravity dependent dispersion effectively limits seed dispersal to the area immediately under or

downhill from the the fruiting body of the parent. Many seed predators are density- or distance-responsive, therefore the lack of a long-distance disperser for *Pritchardia*, may also be directly related to the high percentage of predator damaged seeds (97.4%). The occurrence of only three seedlings and no saplings under the 39 trees sampled indicates a low recruitment rate for the Stainback population of *P. beccariana*. It is unclear whether this is simply related to the indiscriminate and comprehensive seed predation under all fruiting adults or is also an effect of elevation, as all three seedlings were found at the upper-most limit of sampling elevation (2720 ft.).

The results of the seed predation work and adult tree distribution described in this study conflict with one another. If seed survival is near zero under the parent plants then trees should not be clumped, which they are. There are two hypotheses which may explain this contradiction. Firstly, it is possible that seed predation had not, historically, been this drastic. Old, mature trees would be clumped with no recruitment under their canopies or anywhere else. Secondly, since there is presumably no substantial seed dispersal occurring, the only place for seedlings to recruit is near parent trees. In this case, even though seed survival is very, very low there may still be enough germination to allow some limited recruitment in the area of some parent plants during their reproductive lifetimes.

The abundance of the introduced invertebrate species, particularly the *Coccotrypes* Scolytid beetle, indicates that low seed survival may be a fairly new phenomena. The palms may have been able to thrive, even without seed dispersers, before seed predators were introduced. The pattern of adult *Pritchardia* distribution today may reflect a senescing population with some recruitment around remaining individuals.

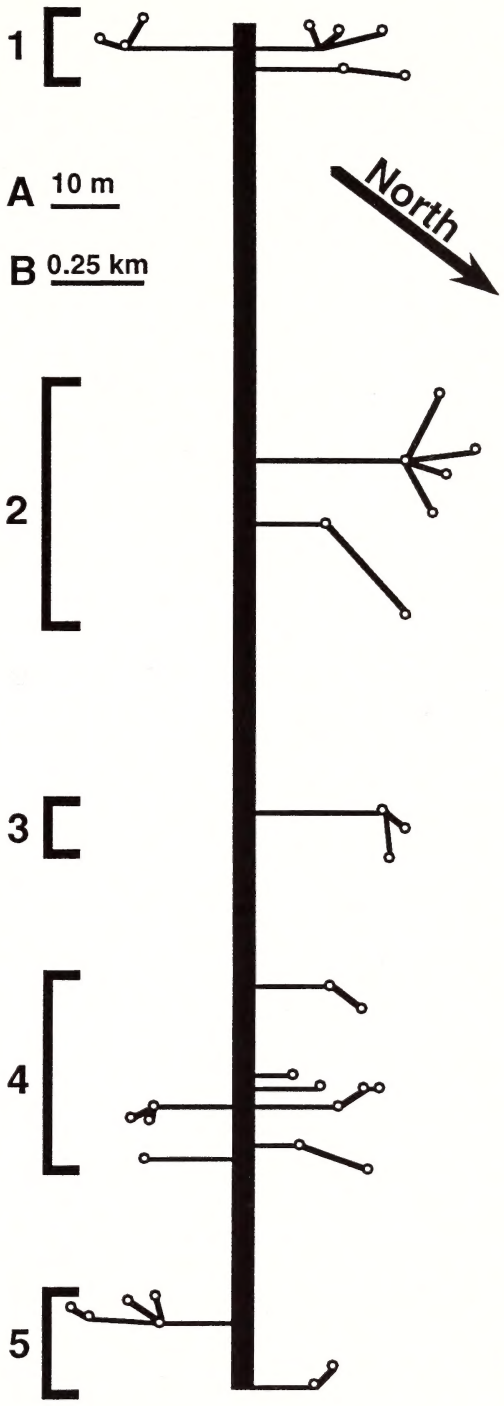

Fig. 9. *Pritchardia beccarniana* plants within 25 m of Stainback Highway (heavy line). Bar scales: A. Highway to nearest plant or plant to plant distance (in meters); B. Distance along highway (in kilometers). Brackets indicate clusters of individuals discussed.

There are few viable management options which will increase recruitment of *Pritchardia* in the wild. Janzen (1971) found that rodents attacking *Scheelea* palm seeds were not eating the seeds themselves, but the Anthribid larvae that were feeding on the seed. It is possible that rats are only secondary consumers of *Pritchardia* seeds, eating seeds which have already been doomed by invertebrate predation. Many of the seeds we found which had signs of rodent attack, also had obvious invertebrate exit/entrance holes. It is quite likely that removal of rats from an area would not improve the survival of future crops of *Pritchardia* seed.

It is not known whether *Pritchardia* populations of *P. beccariana* or any other species are stable, increasing, or decreasing. Given the seed predation levels of P. beccariana and the extremely restricted distributions of some other *Pritchardia* species (Wagner et al. 1991), population decline is the most probable scenario. The best hope for the maintenance of large numbers of individuals for any *Pritchardia* species may be greenhouse germination of seeds followed by outplanting. *Pritchardia* are long lived plants and even infrequent outplanting may be enough to greatly increase overall tree density and population size for many of the species.

ACKNOWLEDGEMENTS

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Appendix 1. Bugs collected on Pritchardia plants. Location of collections listed in parenthesis.

Diptera

Otitidae

Acrosticta apicalis (Wiliiston) -- adventive on all islands in Hawaii. (Lyon)

Micropezidae

Taeniaptera angulata (Stainback)

Coeleoptera
Anthribidae
Araecerus fasciculatus (DeGeer) (Stainback, Puu Honua and Lyon)
Scolytidae
Coccotrypes persicae (Hopkins) (Stainback)
Hypothenemus sp. - 1 (Puu Honua)
Nitidulidae -Lyon *Pritchardia*
Lepidoptera
Gelechiidae
Thyrocopa sp. (Stainback)
Coeleoptera
Nitidulidae
Sp. - (Stainback)
Diptera
Drosophila
Drosophila melanogaster (Stainback and St. John)
Dermaptera
Sp. - (Stainback)

***Pritchardia hillebrandii* (Kuntz) Becc. (From Wagner et al. 1990)**

Status of the *Marsilea villosa* Population at 'Ihe'ihelauakea Crater, O'ahu

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ABSTRACT. Results of a monitoring study based on Wester's 1994 survey grid for the 'Ihe'ihelauakea Crater population of *Marsilea villosa*, O'ahu show that weeds in the crater are not increasing. This is due to a decrease in the grass *Panicum maximum* around the perimeter of the population and a decrease in weedy annual forbs on the crater floor. Management plans for the crater include increases in manual weed control and continued monitoring.

Marsilea villosa Kaulfuss is an endemic Hawaiian fern know as 'Ihe'ihe which means cross or sorrel-leaf shaped (Bruegmann, 1986). It is currently Federally Endangered. The US Fish and Wildlife Service lists the fern as surviving on O'ahu and Moloka'i with four populations and less than 2000 individuals surviving. Through out the Pacific Islands there are five other species in the *Marsilea* genus. The other species originate in South America, North America, India, and the East Indies (Gupta, 1962). Bruegmann (1986) felt that *M. villosa* is derived from the western North American species *M. vestita* which it closely resembles.

The order Marsileales has a fascinating reproductive cycle. Unlike its leptosporangeate ancestor ferns that typically produce their spores on fronds, the Marsileales create a structure called a sporocarp that functions like a seed. This is a highly modified frond that has fused along the margins to enclose the spores (Bold et al, 1987). This leaf then becomes sclerified and can persist and remain viable for up to 100 years (Johnson 1985).

Flooding is necessary to complete the sexual part of the *Marsilea* life cycle and vegetative growth usually takes place only when the plant is submerged or in saturated soil. Bruegmann observed that sporocarp production begins immediately as the soil is drained. Although 'Ihe'ihe may be more drought adapted than other *Marsilea*s it must be flooded to reproduce sexually and grow vegetatively. For a more complete description of the behavior of *M. villosa* in response to environmental conditions, see Bruegmann (1986).

This fern is somewhat unusual in that it is a vernal pool species. However, *Marsilea* typically does not thrive in continual submersion. It can sprout, and grow vegetatively under shallow water for some time but eventually the plant declines. Field observation indicates that shade restricts *Marsilea* leaf production (Kotenko, 1981). This limits the suitable pools to those found in open habitat (Johnson, 1986).

In Hawai'i, pools in arid environments are probably the only ones that remain open and unencumbered due to the colonization of vernal pools in mesic areas by woody plants. These pools have been found in the leeward parts of Moloka'i, Ni'ihau, and O'ahu (Wester, 1994). Craters that have a clay pan or otherwise impermeable floor are good candidates for *Marsilea* habitat. Another vernal pool habitat are the taro (*Colcasia esculenta*) fields where many of the first specimens of *Marsilea villosa* were collected (Forbs, 1920).

Johnson (1986) felt that *Marsilea* might be a colonizing plant rather than a member of a climax community. Several ofthe features ofthe fern's life history support his theory. *Marsilea* has two mechanisms for dispersal, the rhizome apex the the resistant sporocarp. Because it does not usually occur in streams where the rhizome could be uprooted and redeposited the sporocarp that may be ingested by water birds is the more likely dispersal package.

What may be the most relevant to the fern's appearance in Hawai'i and its distribution were several studies that examined the sporocarp's ability to survive ingestion by ducks and other water birds. *Marsilea villosa* is probably derived from *M. vestita* that was brought over by a bird from North American (Bruegmann, 1986). Migratory water birds from North America were found to have ingested *Marsilea* sporocarps and the range of *M. vestita* is concentrated over the major flyways of North America (McAtee 1918).

If *Marsilea* is a bird dispersed weedy colonizer then it may be facing problems similar to other bird dependent Hawaiian plant species. The water birds that would have carried it to the next open pool are no longer numerous. It's decline in any one location may be attributed to the transitional nature of the vernal pool habitat or to infrequent flooding. The introduction of weedy grassed may also reduce the habitat available to the fern by shading otherwise open pools.

The largest known population of *Marsilea villosa* occurs in the 'Ihe'ihelauakea crater on the Koko Head peninsula in Southeast O'ahu 21°15'N latitude, 157°42'W longitude (US Board on Geographic Names, 1956). 'Ihe'ihelauakea Crater is a shallow depression on the makai end on the peninsula, Fig. 1. The area is part of a vent system called the Koko Fissure. The soil in 'Ihe'ihelauakea Crater is a Koko silt loam with moderate permeability and slow run off (USDA, 1972). This supports the fern population and an assemblage of weedy grasses and forbs in the basin of the crater.

Following the European colonization of Hawai'i the headland was grazed as part ofthe Bernice Pauhi Bishop Estate. Possibly many of the grasses found at the site were introduced at this time as fodder along with *Leucaena leucocephala* and *Prosopis pallida.* It was sold in 1927 to the City and County of Honolulu to be leased for agriculture, possibly for continued grazing through the 1940's (Hawai'i Territorial Planning Board, 1939). By 1940 Scott noted that *P. pallida* had covered what he called barren rock (Scott, 1968). After WWII the top 2.7 hectares of the peninsula was leased to FAA. Since this time the area has presumably not been used for grazing, but the site was used for four-wheeled recreation until 1987. At that time, signs were posted at the entrance to the crater announce that it is the "Ancestral Home of 'Ihe'ihelauakea" which seemed to be effective.

'Ihe'ihelauakea Crater is now cooperatively managed by the City and County of Honolulu, The Nature Conservancy of Hawaii, and the U.S. Fish and Wildlife Service. Access to the area via the FAA road is restricted to FAA workers, Park Service, a select group of fishermen, and conservation organizations with their volunteers.

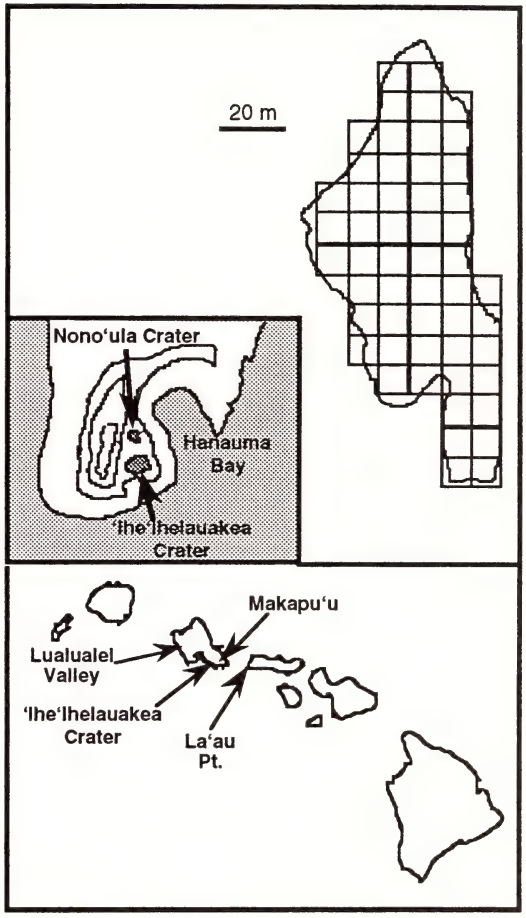

Fig. 1. Map of the crater floor on the southeastern end of O'ahu in the Hawaiian Islands. Grid overlay in 'Ihe'ihelauakea Crater was designed by Wester (1994). Insets show the position of the crater on Koko Head peninsula and the position of all known extant populations of *M. villosa* in the Hawaiian Islands.

The area experiences seasonal rain from October through March with one to several storms every year that typically drop more than 660 mm total (Taliaferro, 1959). Wester estimated that the crater floods about once every six years. The Pauko Drive 723.4 rain gauge is the closest to the crater. It is about 4 km west at 2.6 m elevation. The years between Wester's last published survey in 1991 and 1996 were generally dry, and the crater probably did not flood (Table 1). This may be a factor in determining weed coverage. *Marsilea* is probably able to maintain itself in these years by resprouting from its rhizome (Bruegmann, 1986). Unfortunately, the crater did not flood after the recent November storms.

Wester's study that showed that weeding had no significant effect on the density of the weed species by the following year. The groups managing the area used little active weed abatement measures from 1992 to 1996 (Crumner, personal communication). During a routine visit to the crater in the early growing season of 1996 there was concern over the perceived weed coverage.

METHODS

The Koko Head Peninsula vegetation and the plots established by Wester in 1988 were re-surveyed in October 1996. The *Marsilea villosa* population was divided up into 53, 10 X 10 meter quadrats with wooden stakes marking the grid at the perimeter of the crater. The cover and type of vegetation in the quadrats was identified. Because it was past the growing season and some weeding had been completed by The Nature Conservancy, results of the survey may not be comparable to Wester's results that were recorded in early spring.

Most of the weeds had died back and were difficult to identify to species but the extent of their previous cover could be estimated. The 'Ihe'ihe was identified by the rhizomes on the soil surface and the presence of old stipes. Some of the weed cover had been removed after the growing season by TNC staff. This was mainly along the south and east sides. The vegetation was recorded in the following categories: *Panicum maximum* only; grasses including *P. maximum*; *Sida fallax*; annuals including *S. fallax*; *Prosopis pallida*; and *Marsilea villosa*. The cover and frequency of each of the categories were compared to Wester's results by combining his species results into categories (as before).

Table 1. Precipitation for Puako Drive 723.4 data recording station (National Oceanographic and Atmospheric Administration 1987-95). Average annual rainfall (AAR) is measured in mm.

Year	AAR
1987	965
1988	826
1989	920
1990	903
1991	989
1992	710
1993	609
1994	440
1995	365
Average since 1977	762

RESULTS

A brief vegetation survey of Nono'ula Crater (approximately 100 meters north of 'Ihe'ihelauakea Crater) was completed. It has well defined walls that range in height from two to eight meters. The soil appears to be a silty loam - similar to 'Ihe'ihelauakea with a 3 to 10 centimeter cover of *Panicum maximum* Jacq. stems. The vegetation was fairly consistent through out the crater. There is a canopy of *Prosopis pallida* HBK trees two to six meters in height at a distance of three to ten meters apart. The canopy is fairly open with occasional large fallen trees. *P. maximum* has nearly 100% coverage as the understory and grows in dense clumps. *Bidens pilosa* L., *Sida fallax* Wapl., and *Waltheria indica* L. occurred only occasionally.

'Ihe'ihelauakea crater is a relatively shallow depression on the makai end of the peninsula. The depth of the crater is less than one meter. The soil is also a silty loam but with less organic debris than in Nono'ula. The floor of the crater is dominated by the rhizomes and stipes of *Marsilea villosa*. A corridor of grass runs the length of the site and may have been a trail through the crater at one time. The tracks of the four wheel drive vehicles that used the site in the early 1980's are no longer apparent. The disturbed areas were apparently colonized by weeds. The crater is bordered by an association similar to the one that is dominant in Nono'ula. The *Prosopis pallida* trees are wind pruned at the edges of the basin up and grow to four meters tall with a dense understory of *Panicum maximum*. The weedy species appear at the

margins, along the trail and scattered over the floor of the crater.

When I visited the site the *P. maximum* had regrown from being mowed but was not as tall or dense as the stands surrounding the area which had not been mowed. There had not been sufficient rainfall since the weeding to see evidence of regrowth of the other weeds. *Sida fallax* was occasional through out the site, but did not produce stands or extensive cover.

The *Marsilea villosa* cover in the crater for 1996 appeared most similar to the pattern that Wester observed in 1988 (Wester, 1994) (Fig. 2). He described the areas of highest cover as occurring in a ring around the edges of the survey site. The resolution of the 10 by 10 meter plots does not allow the 2 meter sward of *M. villosa* to graphed, it can be most easily observed at the western edge of the site at 3 to 5 meters in towards the center of the crater from *Prosopis pallida.* The reason for this pattern may be due to the flooding in the crater or the regrowth in the areas that were disturbed by the off-road vehicle use. If flooding is the reason for the ring then it is historical, since the crater has probably not flooded in recent years. The ring may have been at some optimal water depth for the growth of the *Marsilea* and the fern persisted in that pattern by vegetative growth from an impenetrable mat of rhizomes. *Marsilea* also covers the crater floor but at a lower density. The past vehicle use caused large areas of the crater floor to be disturbed. According to Bruegmann, the *Marsilea* may still be recovering in these areas where weeds were moved into the crater floor replacing what was bare soil.

In comparing the pattern of *Marsilea* density to the weedy species, the fern appears to persist throughout the crater floor and diminish at the edges of the crater where the grasses are most dense. It grows with an assemblage of annual species in the open basin of the crater. It is not certain that the competitively sparse annual forbs and *Sida fallax* affect its coverage.

Panicum maximum is a highly invasive grass and is the focus of the management efforts. Wester identified it in a 1984 aerial photograph as occurring in one large and two small patches on the west side of the crater. Marie Bruegmann (U.S.Fish and Wildlife; personal communication) confirmed that this was generally the case in 1986 when she was completing her work in the area. The die back of the *Prosopis pallida* trees due to the leucaena psyllid may have allowed the grass to increase. This insect pest caused the trees to drop their leaves and many died of stress before the pest was controlled. This would have decreased the shading from live trees and opented the canopy of the stand after some of the trees died. In his analysis of *P. maximum* population dynamics, Wester listed it as an increaser/decreaser species. It expanded its coverage from 1988 to 1990 and declined sharply in 1991 after a flood (Table 2). *Panicum maximum* appears to have continued to decline. This may be due to environmental conditions or to successful weeding.

Table 2. Trends in *P. maximum* and annual weed species coverage in the crater floor. Years 1988 to 1991 are from Wester, 1994. Total area 5 300 m2, total number of quadrats is 53. Cover is in square meters.

	P. maximum		Weed Species
Year	Cover	Frequency	Cover
1988	140	18	309
1990	975	31	406
1991	429	24	96
1996	50	8	145

The amount of coverage by annual weeds in the crater is variable (Table 2). Wester identified these plants as decreaser species because they declined after the 1991 flood. The continued low coverage of these species may be due to weeding or to die back since the last rains.

While the annuals appear to grow in an assemblage in the open areas, the grass species are predominately at the edges of the crater with *Panicum maximum* surrounding the crater floor. The annual grasses show a comparatively clumpy distribution by species when examined separately at the perimeter of the crater and under the cover of the *Prosopis pallida* trees. The annual forbs appear to be less common in areas invaded by both annual and prennial grasses.

Discussion

The 'Ihe'ihelauakea crater site is heavily invaded by weeds but the major threat to the *Marsilea* population may be the lack of the flooding necessary to increase. In the dry years the weeds may increase their distribution and the fern may only resprout from its rhizome.

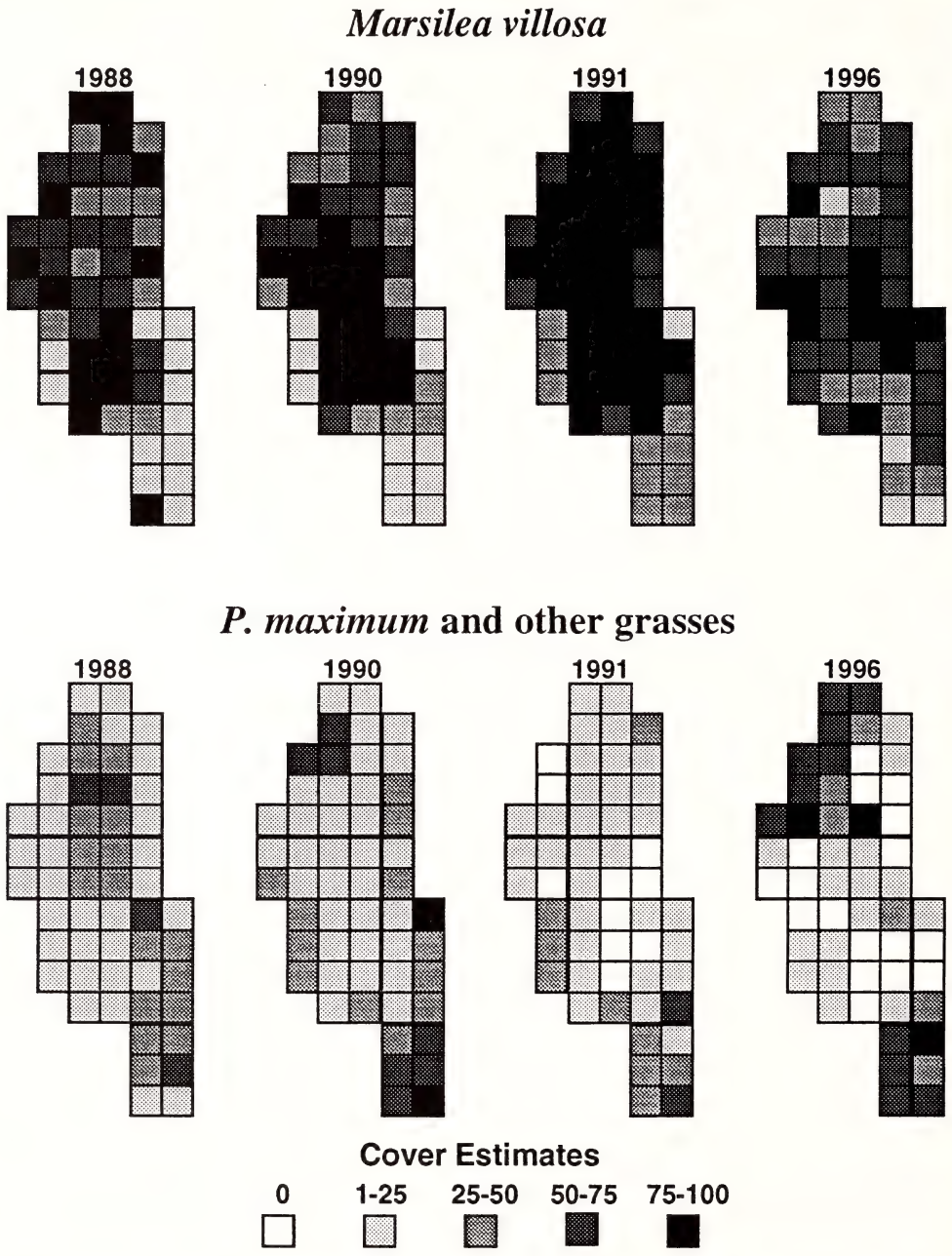

Fig. 2. Estimated cover of *Marsilea villosa* (top) and grasses including *Panicum maximum* in the 'Ihe'ihelauakea Crater. Data for years 1988-1991 are from Wester (1994).

However, the sporocarp bank is probably still viable (Johnson 1985), and with both reduced weed cover and flooding would produce a new generation of *M. villosa*.

Prosopis pallida may change the water table, but because they provide a barrier around the site which in the past has been useful to prevent offroad traffic they will probably remain. There has been some effort to plant *Erythrina sandwicensis* around the site. This appears to have met with limited success, most likely due to the lack of consistent rain in the past few years. An attempt to restore the native dry land forest would be impractical because little is known of what the vegetation was like prior to ranching and the weed in place now would be difficult to remove.

The mowing of the *Panicum maximum* that may be invading the site is probably not effective. In other tropical areas this grass is cultivated for hay and responds to cutting with vigorous regrowth, reaching its original coverage in twenty days (Singh 1995). Although mowing the *P. maximum* early in the growing season while the crater is still saturated may give the 'Ihe'ihe the opportunity to grow vegetatively before it starts to slow its growth and make sporocarps as the soil dry out. Jennifer Crumner believes that a monocot specific herbicide may soon be tested for its effectiveness against *P. maximum* and for its effect on *Marsilea villosa*. Pulling the clumps of *P. maximum* out by hand is labor intensive but may be the most effective way of preventing the grass from taking over the marginal *Marsilea* habitat on the edges of the crater.

I would recommend that the efforts towards conserving this species be broadened to include introducing it into new or historic appropriate habitat on O'ahu and the other islands. This may include recruiting taro farmers to allow it to grow in their fields. Another method might be to introduce it into protected areas, especially where seed eating waterfowl are known to forage.

Acknowledgments

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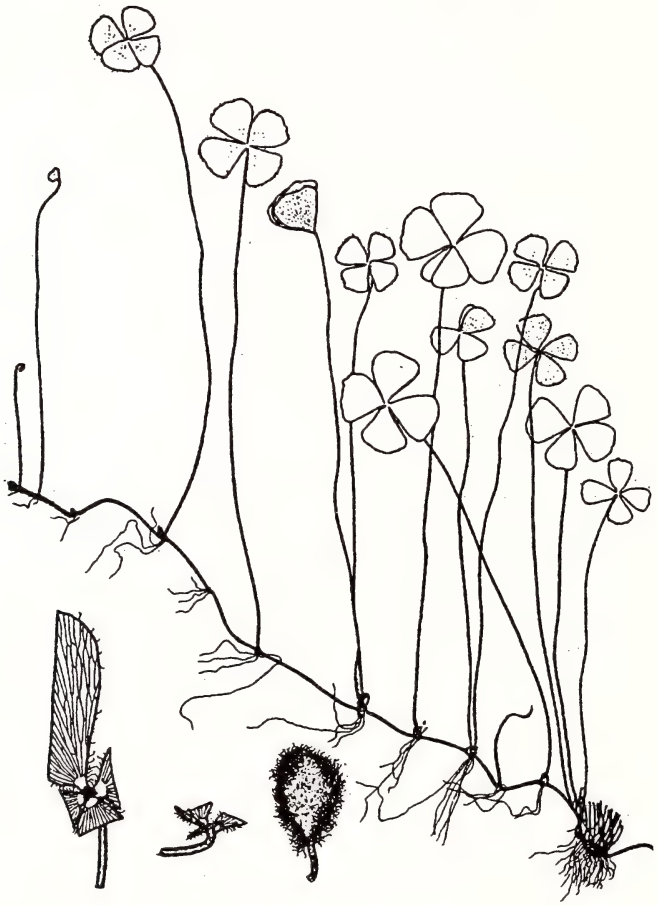

***Marsilea villosa* Kaulf.**

Ridge Vegetation of Mānoa Valley (O'ahu, Hawai'i): Things Ain't What They Used To Be.

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Mānoa Valley, located on the leeward side of the island of O'ahu, Hawai'i, USA, has experienced some of the most extensive modern land-use and degradation of any of the populated Hawaiian Islands (Thrum 1892, MacCaughey 1917, Coulter 1932, Emery 1956; also see Kirch 1982). Such habitat loss and modification has led to a loss of native plant communities in Hawai'i (Sohmer and Gustafson 1987, Hawai'i DLNR 1992).

Two popular conceptions about the contemporary distribution of native Hawaiian plant species are that natural plant associations do still exist on the main Hawaiian Islands at elevations greater than approximately 1,000 feet, and that as one increases in elevation from lowlands to highlands, a greater proportion of native species are encountered. This study was conducted in order to examine the validity of the conceptions as they apply to Mānoa Valley. Not only would the historical development of the valley present a challenge to the ideas, but extensive plantings of non-native species at the back of the valley earlier this century (A. Yoshinaga and R. Baker, pers comms)--as a reforestation effort for watershed conservation--would seem to reduce the likelihood of finding intact native vegetation at low elevations in the valley.

There is interest among local biologists in using Mānoa Valley as a study area for research in ecological restoration. Periodic evaluations of the status of native vegetation in the valley will be important for determining the progress of restoration efforts. Very preliminary studies, such as this one, can serve to prompt others to establish systematic monitoring programs.

Materials and Methods

Study sites. Research was conducted in Mānoa Valley, O'ahu, Hawai'i, on 13 and 26 October, 1996. Vegetation surveys were taken along elevational gradients on either side of the valley (east and west Mānoa). The Honolulu Mauka Trail System (Na Ala Hele) was employed to facilitate this survey. Specifically, the Mānoa Falls, *Aihualama*, and Pauoa Flats trails were followed up the western side of the valley and along the Tantalus ridgeline (the *Aihualama* survey), and the *Kolowalu* and Waahila trails were followed up the eastern side of the valley and along Waahila Ridge (the *Kolowalu* survey). Seven observational samples were taken at intervals of 200 feet of elevation gain for each survey, beginning at 400 feet in elevation and progressing through 1600 feet. Field altimeter readings were standardized between surveys, and the elevations recorded were compatible with elevational contours on USGS topographic maps.

Sampling procedures. At each sampling site, an eight meter transect tape was stretched out parallel to the trail, three meters into the vegetation from the edge of either side of the trail. Three different data categories were then recorded:

Ground cover samples of vegetation less than the height of the second author's knee (approximately 0.5 meters) were taken at each meter mark along the 8 meter transect. Fifty cm of tape was assessed for point-contact of vegetation (vegetation which contacted the meter tape) at each meter mark. Percent cover of live vegetation (by species) and/or "bare ground" (characterized as bare ground or dead vegetation such as leaves or twigs) was assessed. Visual estimates of percent cover were rounded to the nearest 5%. Where possible, the numbers of "individuals" were also recorded. The authors are aware that apparently different plants for modular organisms such as grasses can often be different parts of the same genetic individual. Here, "individuals" is used to mean distinct

plant bodies. Estimates for all ground cover samples were made by the second author.

Understory samples were also taken at each sampling site. "Understory" was characterized as vegetation taller than the second author's knee but not above her head (approximately between 0.5m and 1.75m). Any vegetation in this size class within 15 centimeters of either side of the transect was noted: species, number, and stem diameter were recorded. All understory data were collected by the first author.

The third category of data collected was canopy cover. "Canopy" was characterized as vegetation taller than the second author (greater than approximately 1.75 meters). The canopy cover was assessed by standing on each meter mark of the transect and looking upward. An area of approximately one square meter, directly over the meter mark of the transect tape, was assessed for "percent cover". Tree species and percentages were noted. "Blue sky" was used to denote an entirely leaf-free zone of sky, a hole in, or complete lack of, canopy. Incidental blue sky seen through leaf cover was not noted as "blue sky". Visual estimates of percent cover were rounded to the nearest 5%. Estimates for all canopy cover samples were made by the second author.

Additional data collected at each site were the "exposure" of the site, the compass reading facing outward from the ridge slope at the site (roughly perpendicular to the axis of the ridgeline at the site); the canopy height above the two sampling transects at each elevation; the trail width at the collecting site; and casual notes on the characteristics of the vegetation surrounding the collecting sites. Plant identifications were made by the authors with consultation to Sohmer and Gustafson (1987), Wagner et al. (1990), Merlin (1991), Valier (1995), and Whistler (1995); or plants were identified from field samples submitted to V. Carraway and T. Motley, both of the University of Hawai'i at Mānoa Botany Department. Identified angiosperm plants were assigned to categories of vegetation type and biogeographic origin and distribution following Wagner et al. (1990). Ferns were assigned to categories of origin and distribution following Valier (1995) and identifications by T. Motley (Dept. of Botany, UH- Mānoa.

Data treatment. The authors feel that the vegetation sampling used in this study presents an accurate qualitative representation of the vegetation existing across most of the back of Mānoa Valley. We also feel that these data are quantitatively accurate for proportional evaluations (see analyses below). However, we feel that the nature of our sampling obviates any rigorous statistical analyses. Much of the data collected in this study is categorical. Tabular or matrix representations of these data often contain cells with very low frequencies (fewer than five observations) or zeros. Such data are not amenable to standard parametric statistics and even some nonparametric analyses (such as χ^2 comparisons). Furthermore, we are confident that the major trends in the data presented here are so pronounced that readers will be able to assess the validity of our primary conclusions without need for statistical validation.

RESULTS AND DISCUSSION

Overall patterns. A total of 1198 observations were recorded from both surveys combined. These consisted of 1062 identified plants (either to genus or species), 43 unidentified plants, and 93 observations of no plants; these latter are "no living plants" or "bare ground" recorded in ground cover data, no plants recorded in an understory vegetation observation or "blue sky" recorded in a canopy cover observation (Table 1).

Forty different types of plant were identified, either to genus or species, with two other plants tentatively assigned to taxonomic family, for 30 different families total (see Appendix: List of Species). Of the 40 identified plant taxa, 6 (14%) were endemic, 5 (12%) indigenous and 29 (74%) alien. There is a high probability that the two unidentified species (a grass and a malvaceous shrub) were also alien. This would raise the total of alien taxa to 31.

The preponderance of alien plants is even greater when considered in terms of the numbers of individuals seen. Of the 1062 individual plants identified, 47 (4.4%) were endemic, 45 (4.2%) were indigenous and 970 (91.4%) were alien. These proportions generally hold for the surveys considered separately as well (Table 2).

Native plants were relatively rare in ground cover data and were represented in the highest proportion in canopy samples, in terms of numbers of taxa and individuals observed (Table 3, Figures 1 and 2). This pattern is the

Table 1. Total number of observations of identified plants (Ident.), unidentified plants (Unident.), and no plants (None) for the *Aihualama* and *Kolowalu* surveys. See text for details.

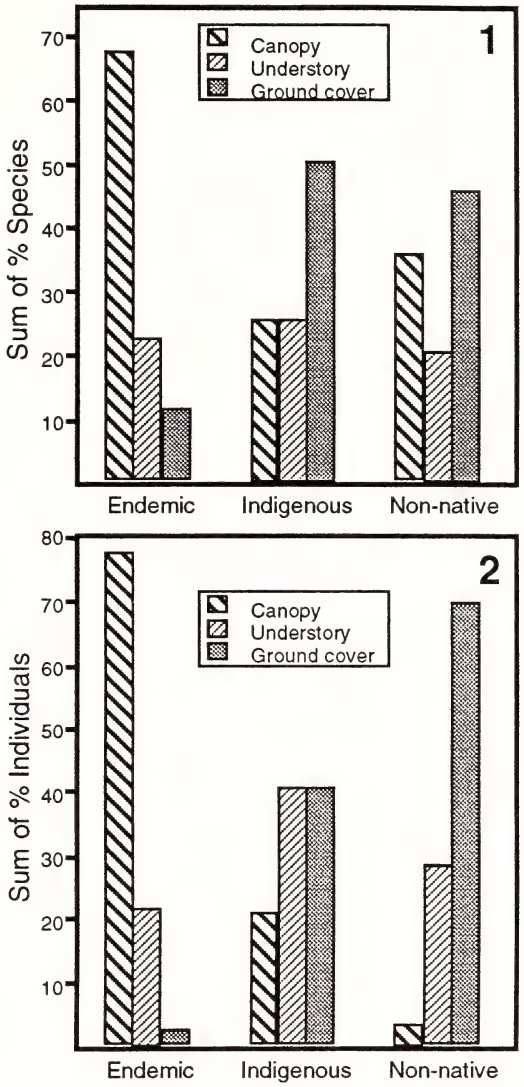
	Ident.	Unident.	None	Total
Aihualama				
No. obs.	546	10	45	601
% obs.	90.8	1.7	7.5	
Kolowalu				
No. obs.	516	33	48	597
% obs.	86.4	5.5	8.0	

Table 2. Numbers of endemic, indigenous and alien plant taxa and individuals for the *Aihualama* and *Kolowalu* surveys.

	Endemic	Indigenous	Alien
Aihualama			
No. of Taxa	3	4	27
% of Taxa	8.8	11.8	79.4
No. of Individ.	12	19	515
% of Individ.	2.2	3.5	94.3
Kolowalu			
No. of Taxa	6	3	16
% of Taxa	24.0	12.0	64.0
No. of Individ.	35	26	455
% of Individ.	6.8	5.0	88.2

Table 3. Total numbers of endemic, indigenous and alien species (above) and individuals (below) identified for each data category. Percentages are of total found in sampling category.

	End.	Ind.	Alien	Totals
Canopy	6	2	18	26
	36	5	301	342
Understory	2	2	10	14
	10	4	194	208
Ground Cover	1	4	23	28
	1	36	475	512



Figs. 1 & 2. The overall proportions of endemic indigenous, and aliens by data category. Fig. 1. By species. Fig. 2. By individual.

same when the data are assessed by survey and by collecting site (data not shown).

There was no significant difference in the numbers of individuals or numbers of identified taxa seen by collecting side among surveys. There was no significant difference in the numbers of endemic, indigenous and alien individuals or species by collecting side within- or among- surveys. Therefore, samples from

different sides of the trail at each sampling site are combined in the following data summaries. There was no discernible pattern in the numbers of individuals or species, or their biogeographic origin and distribution, with respect to sampling site exposure.

Patterns seen with increasing elevation. The overall proportions of native species and native individuals tended to increase with increasing elevation for both surveys. This increase in native taxa was due to increases in all three data categories: ground cover (Figs 3 and 4), understory (Figs 5 and 6), and canopy cover (Figs 7 and 8).

There was much less bare ground recorded for *Aihualama* than for *Kolowalu*, although both had significant proportions of bare ground recorded for their first and fifth collecting sites. The comparative paucity of low-elevation bare ground at *Aihualama* was due to the prevalence of alien species in the ground cover samples. The second through fourth collecting sites for *Aihualama* had roughly 40-60% coverage by two alien grass species (*Oplismenus hirtellus* and *Setaria palmifolia*). [Readers interested in species-specific information may contact the authors for additional data.] Collectively, both surveys showed a large indigenous ground cover component at the upper two collecting sites. These were due entirely to the presence of *Dicranopteris linnearis*.

The canopy cover at the lower two sites for both surveys was heavily dominated by alien species, particularly *Psidium, Cecropia obtusifolia, Schefflera actinophylla,* and *Ficus microcarpa.* (Figures 5 and 6). Overall, more blue sky was seen at *Aihualama*. The endemic species seen at the higher elevations in both cases were predominantly *Metrosideros* species and *Acacia koa.*

The ground covers at the first two sites of each survey were almost entirely the alien grasses, *Setaria palmifolia* and *Oplismenus hirtellus* . The large indigenous component to the upper two collecting sites is due entirely to the presence of *Dicranopteris linnearis*.

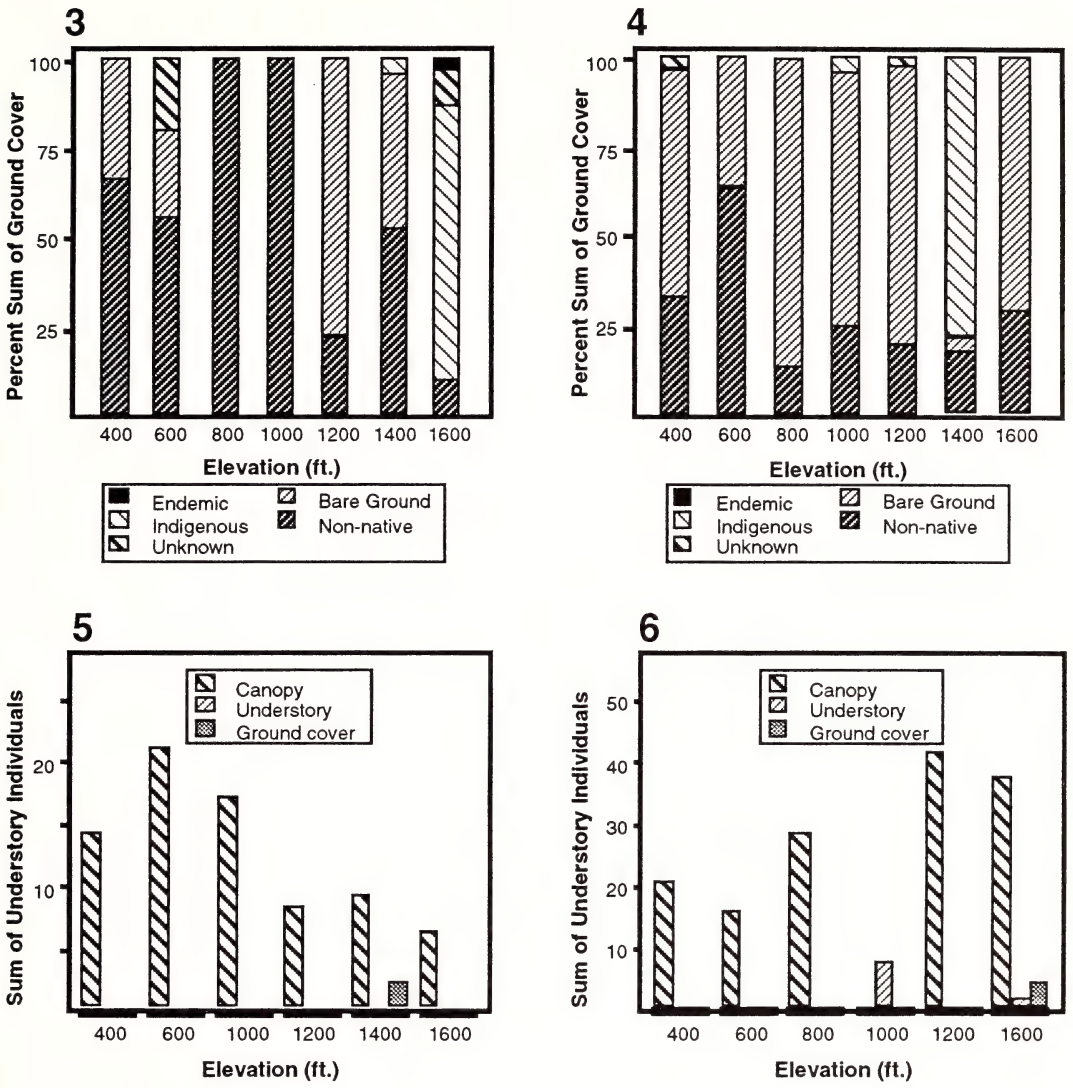
The canopy cover at the lower two sites for both surveys is heavily dominated by *Psidium* spp. plus *Schefflera actinophylla* at *Kolowalu*, and *Psidium* spp. plus *Ficus microcarpa* and *Cecropia obtusifolia* at *Aihualama*. Eight-hundred and 1000 ft. *Aihualama* canopies were dominated by *Citharexylum caudatum*, while *Psidium* species remained dominant at *Kolowalu* until the 1400 ft. sample, whereupon *Metrosideros* species and *Acacia koa* became dominant species in the more dispersed canopy. *Psidium* spp. retook canopy dominance on the ridge crest at 1600 feet on the *Kolowalu* survey. The endemic *Metrosideros* species and *Acacia koa* did not represent a significant proportion of canopy cover until the 1600 ft. sample at *Aihualama*. *Cinnamomum burmannii* was dominant at the 1200 and 1400 ft. elevations.

Canopy height followed the same general pattern for both surveys. Tall alien trees were found in the lower two collecting sites, tree height decreased as the ridge slopes increased, and then canopy heights increased once more as slopes lessened at the ridge crests along the sampling trails.

Table 4. Lower Forest Zone (300-1000 ft.) and Rain Forest (>1000 ft.) vegetation recorded by MacCaughey (1917). End. = endemic, Ind. = Indigenous.

	End.	Ind.	Alien	Total
Forest Zone				
Herbs	3	3	5	11
Shrubs	24	11	17	52
Trees	16	4	3	23
Ferns	11	29	0	40
Total	**54**	**47**	**25**	**126**
Percentages	43%	37%	20%	
Rainforest				
Herbs	22	2	4	28
Shrubs	64	3	0	67
Trees	51	4	1	56
Ferns	65	30	0	95
Total	**202**	**39**	**5**	**246**
Percentages	82%	16%	2%	

Summary of vegetation characteristics. The overall picture of the vegetation suggested by these surveys of the back of Mānoa Valley is as follows. The vegetation observed from 400 to 1200 feet in elevation is almost entirely alien, both in terms of the numbers of species and the numbers of individuals. Canopies on the order of 15 m tall are common on the west (*Aihualama*) and east (*Kolowalu*) sides of theback of the valley between 400 and 800 feet, where the canopy dominants are *Psidium spp.* Alien grasses and sapling, alien trees account



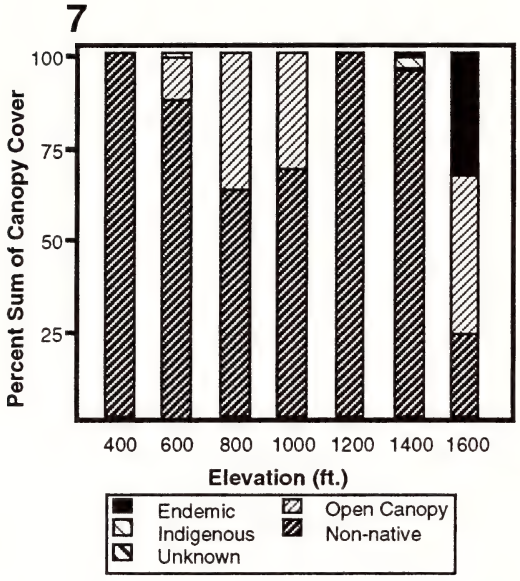
Figs. 3-6. Percentage of ground cover and sum of understory individuals at each site along the altitudinal gradient. Fig. 3. Ground cover at *Aihualama* study site. Fig. 4. Ground cover at *Kolowalu* study stie. 5. Understory individuals at *Aihualama* study site. 6. Understory individuals at *Kolowalu* study site.

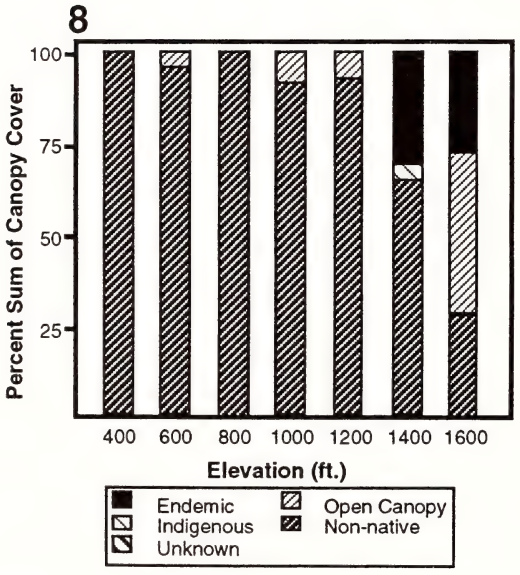
for virtually all of the ground cover vegetation in these areas.

Psidium spp. remain dominant up the ridge slopes sampled by the *Kolowalu* survey, with canopies of roughly 10 m existing up to the 1400 ft. elevation site, above which the canopy becomes more sparse and *Psidium* spp. are replaced by emergent endemic canopy trees, *Metrosideros polymorpha* and *Acacia koa*.

In the *Aihualama* survey area, the canopy

height is lower (by 3 - 4 meters) at the 800 and 1000 ft. sampling sites than at surrounding (lower and higher elevation) sites. This is due to the replacement of *Psidium* spp. by the smaller-statured *Citharexylum caudatum* along open slopes, densely vegetated with *Clidemia hirta* and *Dicranopteris linnearis*. Roughly ten-meter, closed canopies were found again along the *Aihualama* survey at the 1200 and 1400 ft. sites, where dense groves of *Cinnamomum burmannii* presided over bare ground with virtually no undergrowth, except for *Cinnamomum* saplings and an occasional *Cibotium* species. At 1600 ft., the *Aihualama* canopy became largely open again, and of lower height (3 to 4 m), with the dominant canopy trees being endemic *Metrosideros* species and *Acacia koa,* and an undergrowth of *Dicranopteris linnearis*.





Figs. 7 & 8. Percentage canopy cover at each site along the altitudinal gradient. Fig. 7. Canopy cover at *Aihualama* study site. Fig. 8. Canopy cover at *Kolowalu* site.

The dearth of native plant species below 1400 to 1600 feet is relatively new to Mānoa Valley. MacCaughey (1917) reported on the strong representation of native species above 300 feet, in contrast to the largely alien vegetation common in the valley floor at the time (Table 4).

MacCaughey (1917) wrote (pp 570-571):

> *The valley floor is principally occupied by introduced plants, including both weeds and economics. The native vegetation is poor in species and quantitatively insignificant. This condition is in striking contrast with that of the rain-forest, only a few miles distant, where the introduced element is practically negligible.*

Today, we find the proportions of native and alien species reversed at the back of Mānoa Valley (Table 5). While it is obvious that MacCaughey's sampling based upon field notes accumulated over several years is very different from our sampling based upon quick observations, we consider it very unlikely that the vegetation in the back of Mānoa Valley currently resembles the 1917 profile more than it does our contemporary assessment. Indeed, based upon our personal observations, we feel that our characterization of the vegetation composition is likely to be representative of the extant vegetation *en masse*.

Finally, it is our hope that systematic sampling of the Mānoa Valley vegetation will become routine very soon. The heavy degradation of the valley followed by extensive

Table 5. Vegetation recorded in this study for the back of Mānoa Valley, from 400 to 1600 ft. in elevation. End.=endemic species, Ind.= indigenous species

	End.	Ind.	Alien	Total
Aihualama				
Herbs	0	0	2	2
Shrubs	0	0	7	7
Trees	2	0	12	14
Ferns	1	3	3	7
Grasses	0	0	2	2
Vines	0	1	2	3
Totals	**3**	**4**	**28**	**35**
Percentages	8%	11%	80%	
Kolowalu				
Herbs	0	0	1	1
Shrubs	0	0	2	2
Trees	5	0	8	13
Ferns	1	2	2	5
Grasses	0	0	2	2
Vines	0	1	0	1
Totals	**6**	**3**	**15**	**24**
Percentages	25%	12%	62%	

and fairly well-documented reforestation efforts within the last ca. 100 years combine to make Mānoa Valley a potentially valuable study area for biologists interested in many facets of restoration biology. The valley's proximity to major research institutions and the easy accessibility for many environmental studies should act to facilitate future work on Mānoa 's native vegetation. With time and proper management, perhaps some of the figures can be reversed again in vegetation summaries. This will not happen without concerted effort, and that effort must be organized through accurate, useful information collection and dissemination.

Acknowledgements

We would like to thank Ray Baker (Lyon Arboretum, University of Hawai'i), Aaron Lowe (DLNR, State of Hawai'i), Deborah Woodcock (Department of Geography, University of Hawai'i at Mānoa) and Alvin Yoshinaga (Lyon Arboretum, University of Hawai'i) for sharing with us their knowledge and unpublished data on vegetation studies in Mānoa Valley. We are grateful to Vickie Carraway and Tim Motley (both of Department of Botany, University of Hawai'i at Mānoa) for the identification of field samples. We would also like to thank Cliff Morden (Department of Botany, University of Hawai'i at Mānoa) for advice on sampling methods, and Rosemary Gillespie (Center for Conservation Research and Training, University of Hawai'i at Mānoa) for the use of an altimeter.

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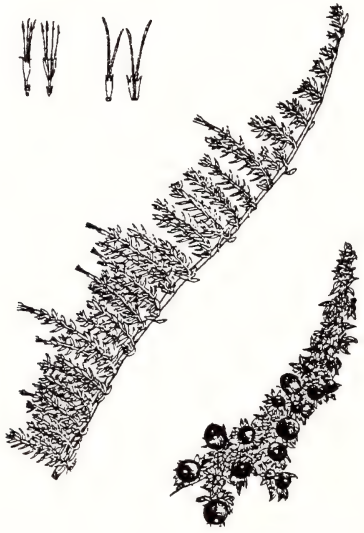
Appendix 1. List of Species. Scientific and family, follow Wagner et al. 1990. "Origin" indicates whether the species are endemic (E), indigenous (I) or alien (N). "Obs" lists on which trail survey the species were observed (A - *Aihualama*, K - *Kolowalu*).

Scientific Name	Family	Origin	Obs
Ferns			
Dryopteris linnearis	Aspidiaceae	I	K
Blechnum occidentale	Blechnaceae	N	K
Cibotium sp.	Dicksoniaceae	E	A, K
Dicranopteris linnearis	Gleicheniaceae	I	A, K
Odontoscoria chinensis	Lindsaeaceae	I	A
Nephrolepis multiflora	Nephrolepidaceae	N	A
Ophioglossum pendulum	Ophioglossaceae	I	A
Phelbodium aureum	Polypodiaceae	N	A
Christella parasitica	Thelypteridaceae	N	A, K
Grasses			
Oplismenus hirtellus	Poaceae	N	A, K
Setaria palmifolia	Poaceae	N	A, K
unknown	Poaceae	N	A
Herbs			
Ageratina riparia	Asteraceae	N	A
Hedychium sp.	Zingiberaceae	N	A, K
Shrubs			
Cordyline fruticosa	Agavaceae	N	A, K
Pluchea symphytifolia	Asteraceae	N	A
Clidemia hirta	Melastomaceae	N	A, K
Ardisia elliptica	Myrsinaceae	N	A
Rubus rosifolius	Rosaceae	N	A
Stachytarpheta urticifolia	Verbenaceae	N	A
unknown	--	N	A
Trees			
Schefflera actinophylla	Araliaceae	N	A, K
Cecropia obtusifolia	Cecropiaceae	N	A
Clusia rosea	Clusiaceae	N	A
Aleurites moluccana	Euphorbiaceae	N	A
Acacia koa	Fabaceae	E	A, K
Cinnamomum burmannii	Lauraceae	N	A
Ficus microcarpa	Moraceae	N	A
Eucalyptus sp.	Myrtaceae	N	A, K
Metrosideros sp.	Myrtaceae	E	A, K
Psidium cattleianum	Myrtaceae	N	A, K
Psidium guajava	Myrtaceae	N	A, K
Psidium sp.	Myrtaceae	N	A, K
Syzygium jambos	Myrtaceae	N	A, K
Grevillea robusta	Proteaceae	N	K
Bobea sandwicensis	Rubiaceae	E	K
Hedyotis terminalis	Rubiaceae	E	K
Wikstroemia sp.	Thymelaeaceae	E	K
Citharexylum caudatum	Verbenaceae	N	A, K
Dioscorea pentaphylla	Dioscoreaceae	N	A
Freycinetia arborea	Pandanaceae	I	A, K
Paederia scandens	Rubiaceae	N	A



***Coprosma ernodeoides* A. Gray**

In Memoriam,

William McKinley Klein, Jr.

On the morning of February 12, Dr. William McKinley Klein, Jr., director of the National Tropical Botanical Garden (NTBG) died of heart failure in Miami, Florida.

Klein served as director to NTBG for 3 years during which time he lifted NTBG from the destruction of Hurricane Iniki with direction and vision. From 1972 to 1977 Klein served as assistant director to Peter Raven of Missouri Botanical Garden. He was then appointed director of Morris Arboretum in 1977. In 1991 he became director of Fairchild Botanical Garden, until his appointment with NTBG.

In addition to his wife Janet, Klein is survived by his four children: Darien of Atlanta, Jennifer Morrison of Ashville, Mass., Melissa and Erica, both of Philadelphia; his mother, Winnifred Klein of Lakewocd, Colorado; and sisters Betty of Golden, Colorado, and Nancy in Sacramento, California.

A memorial service was held at the Kampong Garden, NTBG, Florida, Saturday, February 15 at 4:00 pm. The family requests that contributions be made in his memory to the National Tropical Botanical Garden, PO Box 340, Lawai, HI 96765 USA; or Morris Arboretum, 100 Northwestern Ave., Philadelphia, PA 19118 USA.

Chairman of the Board of Trustees, Douglas Kinney will appoint an acting director to NTBG until a new director is chosen.

***Alphitonia ponderosa* Hillebrand**

Treasurer's Report

JANUARY TO DECEMBER 1996

Dues increases, fundraising efforts, and benevolent members' donations left the Society in good fiscal shape for the year past, a little under five hundred dollars to the good for the whole year. Such welcome news is tempered however, by realizing our biggest expense, the Newsletter, shipped only two new issues in 1996. So, there may be a need for revenue adjustments once the Newsletter gathers a full head of steam, but for now 1996 was a good year for the Society.

In other news, there arose an occasion to produce the IRS letter which determined the Society is a 501(c)(3) organization, exempt from Federal income tax. An exhaustive search of the archives came up short. Discussions with long-time members drew a blank also. At last, an inquiry to the IRS produced results, a new letter with all the particulars. This letter is attached for publication in the Newsletter for ease of reference.

Attention is called to the next to last entry in the income table below. This fifty dollars is the first place prize in the 1995 science fair's Junior division. The winner, Kauka Case, never claimed it. The Society's award letter with the check was returned, undeliverable. If anyone knows this person or how to contact them, please speak up.

Finally, the treasurer would like to thank Lisa Stratton for her thorough financial audit of the Society's books for 1995.

Presented below is a summary of receipts and expenses for 1996:

Income		**Outgo**	
CD Principal	$2,000.00	CD	$2,540.00
Dues	$1,977.00	Copying	$912.11
Raffle	$466.00	Postage	$675.05
Donations	$269.90	Sierra Legal Defense	$250.00
Plant Raffle	$154.00	Science Fair	$241.80
Interest	$107.50	Stationery	$23.92
Earth Day	$99.00		$4,642.88
Void Check #520	$50.00		
t-shirt	$12.00		
	$5,135.40		

Beginning Balance	+	**Income**	-	**Outgo**	=	**Ending Balance**
$2,241.66	+	**$5,135.40**	-	**$4,642.88**	=	**$2,734.18**

The net gain for 1996 is $492.52.

1996 Dues Summary:

Student,	29	x	lyr.	$145.00
	1	x	2yr.	$10.00
Individual,	66	x	lyr.	$660.00
	3	x	2yr.	$60.00
Obsolete rates,	3	x	lyr.	$22.50
	1	x	2yr.	$15.50
Family,	22	x	lyr.	$264.00
Institutional,	12	x	lyr.	$240.00
Obsolete rates,	2	x	lyr.	$20.00
Life,	3			$540.00
Dues Total for 1996				$1,977.00

Respectfully Submitted,

Ron Fenstemacher

Ron Fenstemacher, Treasurer

Internal Revenue Service

Department of the Treasury

District
Director

P.O. Box 2350 Los Angeles, Calif. 90053

HAWAIIAN BOTANICAL SOCIETY
c/o DEPARTMENT OF BOTANY, UH
3190 MAILE WAY
HONOLULU, HI 96822

Person to Contact:
L BARRAGAN
Telephone Number:
(213) 894-2336
Refer Reply to:
EO(0402)96
Date:
JUNE 7, 1996

EIN: 99-6012667

Dear Taxpayer:

This letter is in response to your request for a copy of the determination letter for the above named organization.

Our records indicate that this organization was recognized to be exempt from Federal income tax in MAY 1968 as described in Internal Revenue Code Section 501(c)(3). It is further classified as an organization that is not a private foundation as defined in Section 509(a) of the Code, because it is an organization described in Section 509(a)(2).

The exempt status for the determination letter issued in MAY 1968 continues to be in effect.

If you need further assistance, please contact our office at the above address or telephone number.

Sincerely,

L. Barragan

Disclosure Assistant

Hawaiian Botanical Society

c/o Department of Botany
3190 Maile Way, St. John 101
University of Hawai'i at Mānoa
Honolulu, HI 96822-2279

To: Hawaii Botanical Society
Date: 3/9/97
From: Wisteria Loeffler, President
Re: Accounts Audit

I have reviewed the accounting books and treasurer's report for the Hawaii Botanical Society for the calendar year: 1996. I found them to be detailed and mathematically accurate.

Thank you for the opportunity to review them.

Sincerely,

Wisteria Loeffler
2642 Halelena Pl.
Honolulu, HI 96822
(808)988-5636

News and Announcements

If you have news or announcements that you think would be of interest to the Society members, please submit them for inclusion in later issues of this newsletter. Submissions can be made care of: Cliff Morden, Newsletter Editor, Department of Botany, 3190 Maile Way, University of Hawaii, Honolulu, HI 96822 or via e-mail at cmorden@hawaii.edu.

Web Sites

There are a number of world-wide websites that may be of interest to browse through. Some are of general interest in systematics, others specific for our Hawaiian flora.

Alien Ferns in Hawaii

http://www.lam.mus.ca.us/nhm/departments/research/botany/wilsonferns

For more information, contact:
Kenneth A. Wilson
Department of Biology
California State University, Northridge
Northridge, CA 91330-8303
kwilson@csun.edu or kwilson@bcf.usc.edu

Plants in the Hawaiian Environment

http://alaike.lcc.hawaii.edu/millen/bot130/

For more information, contact:
Priscilla S. Millen
Assistant Professor of Botany
Leeward Community College
94-045 Ala Ike, Pearl City, HI 96782
pmillen@hawaii.edu

Hikes

There is a monthly hike planned for the members of the Hawaiian Botanical Society. Call or e-mail Aaron Lowe for more information at 973-9782 or alowe@hgea.org.

Garage Sale

The first annual garage sale was a huge success. Even though the newspaper failed us (they failed to run the classified ad the day before the sale), there was a steady stream of people coming to browse around and many of them bought items. The total sales for the Society came to $430, enough that the executive committee deemed it worth holding on an annual basis. A BIG thanks go out to Vickie Caraway for organizing the event and spending her day at the sale. Also, thanks to Leilani Pyle and Gerald Toyomura for helping at the sale, Alvin Yoshinaga for use of his truck, and Priscilla Millen for making her home available for the sale.

Annual Plant Raffle

The Hawaiian Botanical Societies annual plant raffle will be held during our regular monthly meeting to be held on May 5th, 7:30 pm in the St. John Auditorium (Rm 011) on the University of Hawai'i at Mānoa campus. Raffle tickets will be $3 for small plants and $5 for larger plants. *Everybody that buys a ticket will come home with a plant!* So, come out and help support your society.

Lab Instructor Position

Wanted, graduate student or person with BS, knowledgeable in basic botanical concepts and Hawaiian flora, both native and introduced, to teach Saturday lab (9am to noon) for Botany 130: *Plants in the Hawaiian Environment* at Leeward Community College, fall semester, 1997. For full description of position, please contact Prof. **Priscilla Millen at pmillen@hawaii.edu or Leeward Community College, 94-045 Ala Ike, Pearl City, HI 96782.**

Awards

Hawaiian Botanical Society Pre-Graduate Research Grants

The Hawaiian Botanical Society Pre-graduate Research Grants Committee is very pleased to announce the winners of the 1997 awards. The Marie Neal-Carey D. Davis Fund generously supports this award with a $500.00 grant. This year all submissions were deemed worthy of support, so the award was divided between the winners according to need. Our winners are:

1. **Michael P. Kupono McDaniel** (University of Hawai'i at Hilo). *"Investigations of Native Species in Succession on Old Sugarcane Lands, Hawai'i Island: Pilot Project."* ($200). Advisor: Dr. G. Gerrish.

2. **Lester L. Knight** (Hawai'i Community College). *"Determination of Optimal Propagation and Growth Conditions for* Sesbania tomentosa *(Ohai)."* ($200, pending state permit). Advisor: Dr. Laura Brezinski.

3. **Leslie Ann Akashi** (University of Hawai'i at Mānoa). *"A comparative anatomical study of* Metrosideros polymorpha *and* Metrosideros polymorpha *var.* nuda." ($50). Advisor: Dr. David Webb.

4. **Maya Lani LeGrande** (University of Hawai'i at Mānoa). *"The development of trichomes on leaves of O'hia Lehua (*Metrosideros polymorpha*)."* ($50). Advisor: Dr. David Webb.

We wish to congratulate all of the winners of this years awards and encourage all interested undergraduates and high school students to consider submitting applications for the 1998 Hawaiian Botanical Society Pre-graduate Research Award.

Hawai'i State Science and Engineering Fair

The Hawaii State Science and Engineering Fair was held April 1st, 1997 in the Neil Blaisdale Center. The Hawaiian Botanical Society sponsored awards for outstanding displays in botany in both the Senior and Junior divisions. Normally two awards are given in each division (first and second place). However, this year there was only one entrant in the Junior division, so three awards (first second and third) were given in the Senior division.

Senior Division

First Prize: **Melissa Carr** (Castle High School). *"The Origin and Relationships of* Rubus macraei *(Rosaceae)."* Prize included $50, a botanical Society T-shirt, a copy of Dr. I. A. Abbott's book *Lā'au Hawai'i*, and one year membership in the Hawaiian Botanical Society.

Second Prize: **Maria Lorence, Malia Parker, and Lynne Yamamoto** (Kaua'i High and Intermediate School). *"Allelopathy: Native or Alien."* Prize included $25, botanical Society T-shirts, copies of Dr. I. A. Abbott's book *Lā'au Hawai'i*, and one year membership in the Hawaiian Botanical Society.

Third Prize. **Jason Ching.** (Mililani High School). *"Antibiotics in Native Hawaiian Plants."* Prize included a botanical Society T-shirt, a copy of Dr. I. A. Abbott's book *Lā'au Hawai'i*, and one year membership in the Hawaiian Botanical Society.

Junior Division

First Prize: **Ariel Thomson** (Island School). *"Can Hawaii's Native Plants Adapt to Hydroponics?"* Prize included $50, botanical Society T-shirts, copies of Dr. I. A. Abbott's book *Lā'au Hawai'i*, and one year membership in the Hawaiian Botanical Society.

Minutes of the Hawaiian Botanical Society

December Meeting

• The December 2nd meeting of the Hawaiian Botanical Society was called to order by Wisteria Loeffler, president.

• **Guests.** Mary Rodgers was introduced as a guest. The minutes were approved as read.

• **Treasurer's Report.** The treasurer's report was given by Ron Fenstamaker.

• **Membership Report.** Alvin Yoshinaga, membership chair, reported a total of 190 members in the Society.

• **Old Business.**

• Old business included the need for an additional judge for the science fair; Tim Motley volunteered.

• Election of officers for 1997. Nominated were:

Gerald Toyamura Director of the Board
Alvin Yoshinaga - Director of the Board
Wisteria Loeffler - President
Curtis Daehler - Vice president
Vickie Caraway - Secretary
Ron Fenstamacher - Treasurer

A motion was made and seconded to appoint the nominees by acclimation.

• **New business.**

• Announcement of the December hike to Pahole Natural Area Reserve, to be led by Bill Garnett.

• Priscilla Millen of Leeward Community College announced the showing of the television program, Conservation of Endangered Native Hawaiian Plants, on channel 55 or 3. This program is hosted by Priscilla and Gray Ray of the Center for Plant Conservation. Contact Priscilla for more information concerning obtaining a copy of the video.

• Reese Liggett of the Sierra Club announced the formation of the Community Action Group for Kaena Point. Their meetings are held the first Tuesday of every month at the Surf Center, Alii Park in Haleiwa. Botanical Society members and concerned citizens are encouraged to attend these meetings.

• The possibility of the Society sponsoring a garage sale was discussed and will be held in the near future.

• Pat Conant announced that Dr. Jean-Yues Meyer, Minister of Research at French Polynesia, is in Hawai'i for 10 months. He can be contacted at Volcano or Haleakala National Park.

• Another announcement was the publishment of a new list of endangered Hawaiian plants.

• **The Plant of the Month** was given by Lou Santiago on hau, *Hibiscus tiliaceus*.

• **Guest Speaker.** Speaker of the month was Paul Higashino from the Kaho'olawe Island Reserve Commission.

January Meeting

• The January 13 meeting of the Hawaiian Botanical Society was called to order by Wisteria Loeffler, president. The minutes were corrected and approved.

• **Treasurer's Report.** Wisteria Loeffler volunteered to audit the society's accounting, as requested by the treasurer, Ron Fenstamaker.

• **Membership Report.** Three new members were approved by the society and

• **Old Business**

• Discussion of the location of the fundraising garage sale. Priscilla Millen volunteered to have the sale at her house.

• David Henkin of the Sierra Club Legal Defense Fund updated the membership on the critical habitat lawsuit. The intent to serve letter was sent to the Fish and Wildlife. The response was there was no plan to designate critical habitat for endangered plants. The

Legal Defense Fund will be bringing the lawsuit against Fish and Wildlife in the month of January.

- **New Business**
  - Mindy Wilkinson volunteering to assist the newsletter editor.

  - Ted Green asked for volunteers with money to assist with collecting in the Philippines.

  - Gary Ray of Center for Plant Conservation ask for volunteer monitors to adopt rare Hawaiian plant populations for the CPC Genetic Safety Net program. Gary also announced the availability of a directory of people in Conservation in Hawai'i, published by CPC.

  - An international symposium on botanical gardens sponsored by Garden Club of Honolulu and Hawaii's botanical gardens was announced. The meetings will be held Monday, Feb. 24 with botanical gardens having open houses February 23, 12-4.

- **The Plant of the Month** was *Spartina alterniflora* - A Threatening Invader of Pacific Estuaries, given by Curtis Daehler of the University of Hawai'i Department of Botany.

- **Guest Speaker.** John Mood of Waimea Arboretum and Botanical Garden, the main speaker for this month, about the Gingers of Sabah, Malaysia.

February Meeting

- The February 3 meeting of the Hawaiian Botanical Society was called to order by Wisteria Loeffler, president. The minutes were approved as read.

- **Membership Report.** Alvin Yoshinaga, membership chair, reported a total of 195 members.

- **Treasurer's Report.** Ron Fenstamacher, gave the treasurer's report for 1996.

- **Old Business**
  - Sierra Club Defense Legal Fund January press conference for the critical habitat lawsuit. James Kwon officially represented the Botanical Society at the conference and Sheila Conant gave a brief summary of the meeting.

  - March 8th fund-raiser, a garage sale to be held at the home of Priscilla Millen.

  - The membership voted to charge $5 per copy of old newsletters and to publish an index of the newsletter articles on the world wide web.

- **New Business**
  - The Society will participate in this year's Earth Day celebration. Orlo Steele volunteered to chair the committee.

  - John Obata volunteered to bring native plants to the monthly meetings to sell as a fundraising project. These plant sales will be in addition to the annual plant sale at the May meeting of the Botanical Society.

  - Announcements included Roz Wright asking for support of the society's membership in supporting Senate bill 454 and House bills 374, 454 and 730. These bills deal with mountain and shoreline access to public hiking trails.

  - Arron Lowe of Land and Natural Resources announced his budget for trail maintenance had approximately $1000 per year earmarked for Manoa Cliff Trail. Arron suggested the Botanical Society do the monthly upkeep of the trail. A motion was made for the board to discuss the proposal further with Arron.

  - Pat Conant announced that the *Miconia* spread on O'ahu seemed to be decreasing and announced a *Miconia* distruction meeting in February.

- **The Plant of the Month** was *Marsilea villosa*, given by Mindy Wilkinson of UH Botany Department.

- **Guest Speaker.** Speaker of the month was Joby Rohrer of the US Army Garrison, giving a Update and the Future Plans of the Army Ecosystem Management on O'ahu.

March Meeting

• The March 3 meeting of the Hawaiian Botanical Society was called to order by Wisteria Loeffler, president. The minutes were approved as read.

• **Treasurer's Report.** The treasurer's report was given by Ron Fenstemacher.

• **Membership Report.** Alvin Yoshinaga, membership chair, noted the passing of William Klein, Director of National Tropical Botanical Gardens. Three new members were approved.

• **Old Business**
• Discussion of the Society's participation in Earth Day and the March 8th garage sale.

• **New Business**
• Announcements were the Botanical Society hike to Koko Head's Ihi'ihi Lauakea preserve and a call for articles for the next newsletter.

• Priscilla Millen announced the recipients of the First Botanical Society grant. The winners were • Michael McDaniel of UH Hilo (Investigation of Native Species in Succession on Old Sugarcane Lands, Hawaii Island: Pilot Project - $200); • Lester Knight of Hawaii Community College (Determination of Optimal Propagation and Growth Condition for Cultivation of *Sesbania tomentosa*, Oahu - $200): • Leslie Akashi of UH Manoa (A Comparative anatomical study of *Metrosideros polymorpha* and *M. polymorpha* var. *nuda* - $50); • Maya LeGrande of UH Manoa [The Development of Trichomes on Leaves of 'Ohia lehua (*Metrosideros polymorha* L.) - $50].

• Pat Conant announced a *Miconia* eradication hike for March 27 and asked the membership to report any Oahu sightings of *Tibochina herbacea* .

• **The Plant of the Month** was given by Don Gardner, Cooperative Parks Studies Unit of University of Hawaii, on New and Exciting Pathogenic Forest Fungi.

• **Guest Speaker.** The speaker for March was Mark Merlin of the Biology Department of University of Hawaii, Manoa. His topic was Betel Nut (*Areca catechu*) and Kava (*Piper methysticum*): Two Traditional Psychoactive Plants of the Pacific.

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- *Genetic variation among Hawaiian cultivars of 'uala (*Ipomoea batatis*).* D. N. Adams & C. W. Morden
- *Effects of population fragmentation on genetic variation of* Haplostachys haplostachya, *an endangered Hawaiian mint.* W. Loeffler & C. W. Morden
- *Identification of* Dubautia paleata × D. raillardioides *hybrids using RAPD markers.* D. Carino & C. W. Morden

Do you have something you would like to contribute to the *Newsletter*? All contributions are welcome. They may be technical articles related to on-going research, comments about current events, or field observations you may have made from a recent expedition. Contributions may be sent to the *Newsletter* Editor via manuscript, disc (please provide hard-copy also), or E-mail at:

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SLETTER OF THE HAWAIIAN BOTANICAL SOCIETY
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